EXPANSION MODULE AND NETWORK FOR AVIONIC DEVICES

BACKGROUND OF THE INVENTION

1) Field of the Invention

The present invention relates to the connection of electronic devices to an aircraft and, more particularly, relates to an apparatus for providing a connection for electrical transmissions between an aircraft and one or more electronic devices such that signals representative of the transmissions can be generated and communicated therefrom.

2) Description of Related Art

Conventional aircraft electronic systems include a number of electronic avionic devices, each of which is provided in a separate enclosure. Each device, which is typically referred to as a line replaceable unit (LRU), is secured to a tray that is connected to a shelf on the aircraft. For example, Figure 1A illustrates a conventional tray **10** for securing a line replaceable unit (LRU) **12** on an aircraft. The tray **10** is typically secured to a shelf, which can hold multiple trays **10**. Each tray **10** can correspond in size to the LRU **12** disposed thereon. An aircraft connector **14** at the back of the tray **10** connects the LRU **12** to the aircraft, e.g., to the aircraft wiring system. The aircraft connector **14** can be a single connection device or multiple connection devices. The aircraft connector **14** can be an ARINC-type connector, i.e., connectors that include a plurality of mating pin and socket terminals in accordance with specifications set forth by ARINC, Inc., such as ARINC Specification 600. A corresponding ARINC-type connector **16** can be provided on the LRU **12**. The aircraft connector **14** can be secured to the tray **10** so that the connector **14** engages the LRU **12** when the LRU **12** is disposed in the tray **10**. The LRU **12** can communicate by sending and/or receiving electrical signals through the connector **14** and, hence, the aircraft wiring system. Thus, the LRU can receive information, such as data from flight control devices, sensors, and the like. For example, one LRU receives data regarding the position, elevation, speed, and orientation of the aircraft via the aircraft wiring system from sensors or other devices on the aircraft. The LRU

uses the data to generate display signals that control the devices in the cockpit to graphically display the data.

In some aircraft electronic systems, the information that is communicated to and from the LRUs is also transmitted to additional systems, such as a crew information system. The crew information system can be used for a variety of purposes, including tracking and scheduling maintenance operations, verifying the completion of flight procedures, recording or transmitting information for training, and the like. However, retrofitting aircraft to include such additional systems can be difficult and costly. For example, modification of the LRUs to include additional functionality can be prohibitively expensive and can require lengthy requalification and recertification procedures to verify the proper operation of the LRUs. Devices adapted to communicate with these additional systems can instead be housed separately from the existing LRUs, and Y-connectors can be disposed between the aircraft wiring system and the existing LRUs so that the electrical transmissions therebetween can be communicated to the devices adapted to communicate with the additional systems. However, such changes to the aircraft wiring system to accommodate the additional systems can be costly. Further, in some aircraft, there is limited space available for the addition of components. Even if sufficient space is available in the aircraft for the additional systems, the electrical cables required for connecting the additional systems to the aircraft wiring system can be prohibitively long and large. In some cases, the electrical connection of long wires to the connections between the aircraft wiring system and the LRUs can cause unacceptable interference with the electrical transmissions therebetween. Further, retrofitting requirements for individual aircraft can differ, requiring different connectors, different cables, different placement of additional devices, and the like. This complicates the retrofitting procedures and increases the cost.

Thus, there exists a need for an apparatus for connecting devices to an aircraft for communicating with additional systems, such as devices communicating with a crew information system. The apparatus should allow the connection of additional devices to a conventional arrangement of LRUs so that the devices can receive data communicated between the LRUs and the aircraft wiring system. In addition, the apparatus should preferably minimize or eliminate the need for additional requalification and recertification of the LRUs.

BRIEF SUMMARY OF THE INVENTION

The present invention provides an apparatus and network, each including at least one expansion module for communicating signals representative of electrical transmissions occurring between an aircraft and an avionic device. Each expansion module can be disposed between corresponding aircraft connectors and avionic device connectors, such that the present invention can be used to retrofit existing aircraft. The expansion modules can also be configured to generate signals representative of the electrical transmissions between the aircraft and the avionic devices without substantially modifying those transmissions.

According to one embodiment of the present invention, each expansion module includes first and second connectors having a plurality of electrical terminals configured to mechanically engage and electrically connect to the aircraft connector and the avionic device connector, respectively. The terminals can be pin and socket elements, such as are used in an ARINC-type connector. An electrical circuit, such as electrical paths on one or more printed circuit boards, defines a plurality of electrical junctions between the electrical terminals of the first and second connectors. The circuit is configured to communicate a signal representative of at least one of the electrical transmissions between the avionic device and the aircraft to a communication network, for example, via an Ethernet connection to an Ethernet communication network. The electrical circuit can be connected to a power source, although the expansion module can be configured to provide the electrical junctions for the electrical transmissions between the avionic device and the aircraft even when the electrical circuit is not powered.

According to another embodiment of the present invention, each expansion module is structured to be received by a tray that also receives the avionic device. The tray can secure the avionic device to the aircraft, and the expansion module connects the avionic device and the aircraft when the avionic device is received by the tray.

The present invention also provides a communication network for communicating signals representative of electrical transmissions occurring between a plurality of avionic devices and an aircraft. The network, which includes at least two of the expansion modules, can also include a controller that is configured to receive

the signals transmitted by the expansion modules. The controller can also provide power to the circuits of the expansion connectors. In addition, the network can include a communication device for transmitting data from the communication network via a radio signal to a second aircraft, a satellite, or a ground-based receiver. A data storage device can also be provided for recording data from the network.

According to yet another embodiment, the present invention provides a method for retrofitting an aircraft having a plurality of avionic devices. An avionic device connector of each avionic device is disconnected from a respective aircraft connector, and an expansion module is disposed therebetween so that the expansion module connects the avionic device to the aircraft. Subsequently, an electrical transmission is delivered between the avionic device and the aircraft via the expansion module. The expansion module generates a signal representative of the electrical transmission and communicates the signal therefrom, for example, to a controller via an Ethernet network. The signal can be generated without substantially modifying the electrical transmissions between the avionic device and the aircraft. Further, the data can be stored in a data storage device or transmitted via a radio signal to a second aircraft, a satellite, or a ground-based receiver.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a perspective view illustrating a tray with an expansion module according to one embodiment of the present invention;

Figure 1A is a perspective view illustrating a conventional tray for connecting an LRU to an aircraft wiring system;

Figure 2 is an exploded perspective view illustrating the expansion module of Figure 1 with an avionic device and an aircraft connector;

Figure 3 is an exploded perspective view illustrating the circuit boards of the expansion module of Figure 1;

Figure 4 is a schematic view illustrating a communication network according to one embodiment of the present invention; and

Figure 5 is a schematic view illustrating a communication network according to another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, this invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

Referring now to the drawings, and in particular to Figure 1, there is illustrated a tray **100** according to one embodiment of the present invention. The tray **100** can be connected to a shelf or other support member in an aircraft, and is structured to receive and support an avionic device **110** such as a line replaceable unit. An expansion module **120** is disposed between an aircraft connector **140** and the avionic device **110**. The aircraft connector **140** can include one or more conventional connection devices. As shown in Figure 1, the tray **100** includes a bottom **112** and sides **114** that correspond in size to the avionic device **110** and the expansion module **120**. Thus, the trays **100** of the present invention can be generally longer than conventional trays for securing a particular avionic device **110** so that the tray **100** also accommodates the expansion module **120**.

The aircraft connector **140** shown in Figure 1 is an ARINC-type connector and, in particular, a connector that conforms to the ARINC 600 specification. In particular, the aircraft connector **140** defines a plurality of sockets **142** on a first side **144**. Each socket **142** is structured to receive a crimped pin **146** that is connected to one of a plurality of electrical wires **148** extending to the aircraft, e.g., to an aircraft wiring system **160** disposed throughout the aircraft. The expansion module **120**, shown disconnected from the avionic device **110** in Figure 2, also defines first and second connectors **122, 126**. The first connector **122** is configured to connect to a second side **150** of the aircraft connector **140**. The second connector **126** is configured to connect to an avionic device connector **116** on the avionic device **110**. Thus, the expansion module **120** connects the avionic device **110** to the aircraft so that

the avionic device **110** can communicate through the expansion module **120** with other devices of the aircraft.

The first connector **122** can include a plurality of electrical terminals **124** that mechanically engage and thereby electrically connect to the aircraft connector **140**. Similarly, the second connector **126** can include a plurality of electrical terminals **128** that mechanically engage and thereby electrically connect to the avionic device connector **116**. In particular, as shown in Figure 2, the terminals **124** of the first connector **122** can include a plurality of female socket elements that are configured to receive pins of the aircraft connector **140**, and the second connector **126** can include a plurality of male pin elements configured to be received by female sockets **118** of the avionic device connector **116**. Further, the electrical terminals **128** of the second connector **126** can correspond to the electrical terminals **124** of the first connector **122** in size and arrangement so that the expansion module **120** can be disposed between corresponding avionic device and aircraft connectors **116**, **140**, i.e., an avionic device connector **116** and aircraft connector **140** that are configured to be engaged directly. Thus, the expansion module **120** can be fitted to a conventional avionic device and aircraft connector, for example, to retrofit an aircraft for the purpose of adding a communication network, by disposing the expansion module **120** between the aircraft and respective avionic devices **110** and replacing the conventional trays with trays **100** structured to receive the avionic device **110** and the expansion module **120**.

The expansion module **120** includes an electrical circuit that defines a plurality of electrical junctions, or paths, between the electrical terminals **124**, **128** of the first and second connectors **122**, **126**. For example, each junction can extend between one or more than one of the electrical terminals **124** of the first connector **122** and a corresponding one or more of the terminals **128** of the second connector **126**. Preferably, the junctions are defined by at least one circuit board in the expansion module **120**. As shown in Figure 3, the first and second connectors **122**, **126** are mounted on first and second circuit boards **130**, **132**, respectively, and the two circuit boards **130**, **132** are connected by interboard connectors **134**, **136**, which are also mounted on the respective circuit boards **130**, **132**. The interboard connectors **134**, **136** electrically connect the junctions between the connectors **130**, **132**, which are defined by electrical paths disposed on the boards **130**, **132**, as is known in the art. Thus, each junction can extend from a terminal **124** of the first connector **122**, through

the first board **130**, the first and second interboard connectors **134, 136**, the second board **132**, and the second connector **126**. In other embodiments, the junctions can be defined by one or other numbers of circuit boards, or the junctions can be defined by other electrical components such as wires.

As described above, the expansion module **120** is structured to communicate electrical transmissions between the avionic device **110** and the aircraft wiring system **160**. In addition, the expansion module **120** communicates a signal representative of at least one of those electrical transmissions to a communication network. For example, as illustrated in Figure 3, the boards **130, 132** include convention electrical components **138** such as integrated circuits, transistors, capacitors, resistors, diodes, and the like for generating and communicating signals that are representative of the electrical transmissions between the avionic device **110** and the aircraft wiring system **160**.

The expansion module **120** also includes a port **139** through which the module **120** can receive power and can communicate. For example, the port **139** can include an Ethernet connection, and the expansion module **120** can be configured to communicate via the port **139** to a network that includes other avionic devices or otherwise, as further described below in connection with Figures 4 and 5. Electrical power can also be received through the port **139** for powering the expansion module **120**.

Figure 4 schematically illustrates a communication network **170** according to one embodiment of the present invention for communicating data from a plurality of the avionic devices **110**, designated by reference numerals **110a, 110b, 110c**. Each of the avionic devices **110a, 110b, 110c** is connected to the aircraft wiring system **160** via a respective one of the expansion modules **140**, designated by reference numerals **140a, 140b, 140c**. Each of the expansion modules **140a, 140b, 140c** is connected to a power supply **172**, e.g., through the ports **139** of the modules **140**, to receive power from the aircraft. Although three avionic devices **110a, 110b, 110c** and three expansion modules **140a, 140b, 140c** are shown in Figure 4, any number of avionic devices **110** and expansion modules can be included in the network **170**. The expansion modules **140a, 140b, 140c** are also interconnected via the ports **139**, which can provide Ethernet connections, though other network connections can alternatively be used in other embodiments of the present invention. Further, one or more

additional devices **174** can be connected to the communication network **170**. The additional device **174** can be a computer or other electronic processing device that is configured to receive signals from the expansion modules **140a, 140b, 140c** and store, process, or transmit information based thereon. For example, the additional device **174** can be an onboard computer or an LRU that has radio transmission capabilities. Thus, the additional device **174** can store data received from the expansion modules **140a, 140b, 140c** and/or transmit the data, e.g., to a ground-based receiver, satellite, or other aircraft.

Figure 5 schematically illustrates a communication network **180** according to another embodiment of the present invention. Similar to the network **170** illustrated in Figure 4, the network **180** includes a plurality of avionic devices **110a, 110b, 110c** and expansion modules **140a, 140b, 140c**. In addition, the expansion modules **140a, 140b, 140c** are connected to a controller **182**. The controller **182** is configured to supply power from the aircraft to the expansion modules **140a, 140b, 140c**, though in other embodiments the expansion modules **140a, 140b, 140c** can alternatively be connected to other power supplies. The controller **182** also communicates with the expansion modules **140a, 140b, 140c**, i.e., sends information to and/or receives information from the expansion modules **140a, 140b, 140c**, e.g., via Ethernet connections therebetween. The controller **182** can communicate with a communication device **184**, such as a radio transmitter, that is configured to transmit information based on the signals from the expansion modules **140a, 140b, 140c**. In addition, the controller **182** can include a data storage device **186**, such as a disk drive, optical data recording device, flash memory device, or the like, such that the controller **182** can transmit some of all of the data received from the expansion modules **140a, 140b, 140c** for storing in the data storage device **186**.

Preferably, each expansion module **140** provides the electrical junctions between the aircraft and the corresponding avionic device **110** so that electrical transmissions therebetween occur without substantial interference or modification by the expansion module **140**. For example, each expansion module **140** can be configured to provide the electrical junctions even if the power supply **172** and/or the controller **182** are disconnected from the expansion module **140**. Further, when powered, the expansion module **140** can monitor the electrical transmissions without substantially reducing the voltage or current of the transmissions.

Each expansion module **140** provides signals that are representative of the electrical transmissions that occur between the aircraft wiring system **160** and the respective avionic device **110**. For example, the expansion module **140** can monitor each of the electrical junctions and generate signals that are reproductions of the electrical transmissions. Preferably, the expansion module **140** adapts the data communicated by the electrical transmissions to form a signal that can be communicated over a network, such as the networks **170, 180** shown in Figures 4 and 5. For example, the expansion module **140** can digitize the signals and communicate the data in packets according to a conventional Ethernet protocol. Thus, the plurality of expansion modules **140** can generate signals that are representative of the electrical transmissions and communicate the signals over a common network to the controller **182**, additional device **174**, other expansion modules **140,** and the like.

The networks **170, 180** according to the present invention can be used for a variety of functions on an aircraft. For example, the signals can be used to communicate data relating to the operation of the aircraft according to the electrical transmissions between the avionic devices **110** and the other devices on the aircraft. Such data can include information regarding the position, elevation, speed, and orientation of the aircraft. The data can also relate to the maintenance of the aircraft, the operation or position of the aircraft's control devices, the status of sensors, the display of information in the cockpit or cabin, and the like. This information can be stored and/or relayed throughout a crew information system (CIS). The CIS can also use the information for a variety of purposes. For example, the CIS can record and track maintenance operations, provide maintenance information to the aircraft crew or maintenance personnel, track flight operations and provide operational data to the crew, tracking personnel, and the like. In particular, the CIS can notify the crew if flight operations are not performed or are performed incorrectly or untimely. The data also can be used for accident investigation, simulation, and the like. For example, the controller **82** can relay the information to the communication device for transmission to a ground-based receiver. The ground-based receiver can compile flight information for use in computer-based flight simulation. For example, the receiver can correlate the operation of the aircraft, adjustment of controls by the crew, weather conditions, aircraft characteristics, and the like to provide detailed simulation scenarios for computer-based flight simulation programs for training.

Many modifications and other embodiments of the invention set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.